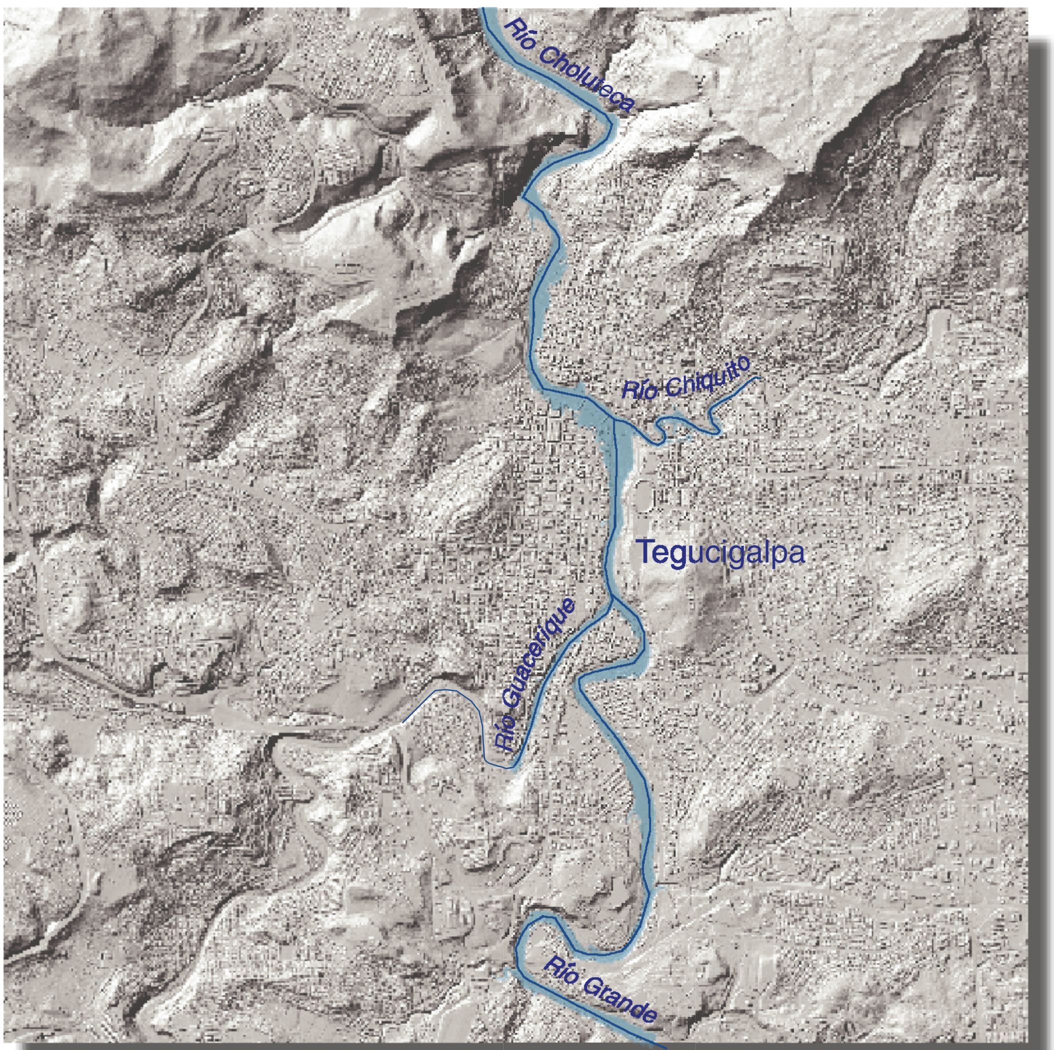
Fifty-Year Flood-Inundation Maps for Tegucigalpa, Honduras

Prepared in cooperation with the U.S Agency for International Development

U.S. Geological Survey Open-File Report 02-261



U.S. Department of the Interior
U.S. Geological Survey

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By Mark C. Mastin and Theresa D. Olsen

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 02-261

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Box 25286, Federal Center
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CONTENTS

FIGURES

TABLES

CONVERSION FACTORS AND VERTICAL DATUM

CONVERSION FACTORS

Multiply	By	To obtain
cubic meter per second (m^3/s)	35.31	cubic foot per second
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
millimeter (mm)	0.03937	inch
square kilometer (km^2)	0.3861	square mile

VERTICAL DATUM

Elevation: In this report "elevation" refers to the height, in meters, above the ellipsoid defined by the World Geodetic System of 1984 (WGS 84).

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ABSTRACT

After the devastating floods caused by Hurricane Mitch in 1998, maps of the areas and depths of the 50-year-flood inundation at 15 municipalities in Honduras were prepared as a tool for agencies involved in reconstruction and planning. This report, which is one in a series of 15, presents maps of areas in the municipality of Tegucigalpa that would be inundated by a 50-year flood of Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito. Geographic information system (GIS) coverages of the flood inundation are available on a computer in the municipality of Tegucigalpa as part of the Municipal GIS project and on the Internet at the Flood Hazard Mapping Web page (http://mitchnts1.cr.usgs.gov/projects/floodhazard.html). These coverages allow users to view the flood inundation in much more detail than is possible using the maps in this report.

Water-surface elevations for an estimated 50-year-flood on Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa were determined using HEC-RAS, a one-dimensional, steady-flow, step-backwater computer program. The channel and floodplain cross sections used in HEC-RAS were developed from an airborne light-detection-and-ranging (LIDAR) topographic survey of the area and ground surveys at bridges. There are no nearby long-term stream-gaging stations; therefore, the 50-year-flood discharges were estimated using a regression equation that relates the 50-year-flood discharge to drainage area and mean annual precipitation. The estimated 50-year-flood discharge is 922 cubic meters per second at Río Choluteca at downstream end of the study area boundary, 663 cubic meters per second at the mouth of the Río Grande, 475 cubic meters per second at the mouth of the Río Guaceriqe, and 254 cubic meters per second at the mouth of the Río Chiquito.

INTRODUCTION

In late October 1998, Hurricane Mitch struck the mainland of Honduras, triggering destructive landslides, flooding, and other associated disasters that overwhelmed the country’s resources and ability to quickly rebuild itself. The hurricane produced more than 450 millimeters (mm) of rain in 24 hours in parts of Honduras and caused significant flooding along most rivers in the country. A hurricane of this intensity is a rare event, and Hurricane Mitch is listed as the most deadly hurricane in the Western Hemisphere since the “Great Hurricane” of 1780. However, other destructive hurricanes have hit Honduras in recent history. For example, Hurricane Fifi hit Honduras in September 1974, causing 8,000 deaths (Rappaport and Fernandez-Partagas, 1997).

As part of a relief effort in Central America, the U.S. Agency for International Development (USAID), with help from the U.S. Geological Survey (USGS), developed a program to aid Central America in rebuilding itself. A top priority identified by USAID was the need for reliable flood-hazard maps in Honduras to help plan the rebuilding of housing and infrastructure. The Water Resources Division of the USGS in Washington State, in coordination with the International Water Resources Branch of the USGS, was given the task to develop flood-hazard maps for 15 municipalities in Honduras: Catacamas, Choloma, Choluteca, Comayagua, El Progreso, Juticalpa, La Ceiba, La Lima, Nacaome, Olanchito, Santa Rosa de Aguán, Siguatepeque, Sonaguera, Tegucigalpa, and Tocoa. This report presents and describes the determination of the area and depth of inundation in the municipality of Tegucigalpa that would be caused by a 50-year flood of Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito.

The 50-year flood was used as the target flood in this study because discussions with the USAID and the Honduran Public Works and Transportation Ministry indicated that it was the most common design flood used by planners and engineers working in Honduras. The 50-year flood is one that has a 2-percent chance of being equaled or exceeded in any one year and on average would be equaled or exceeded once every 50 years.

Purpose, Scope, and Methods

This report provides (1) results and summary of the hydrologic analysis to estimate the 50-year-flood discharges used as input to the hydraulic model, (2) results of the hydraulic analysis to estimate the water-surface elevations of the 50-year-flood discharges at cross sections along the stream profile, and (3) 50-year-flood inundation maps for Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa showing area and depth of inundation.

The analytical methods used to estimate the 50-year-flood discharge, to calculate the water-surface elevations, and to create the flood-inundation maps are described in a companion report by Mastin (2002). Water-surface elevations along Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito were calculated using a HEC-RAS, one-dimensional, steady-flow, step-backwater computer model, and maps of the area and depths of inundation were generated from the water-surface elevations and topographic information.

The channel and floodplain cross sections used in the model were developed from an airborne light-detection-and-ranging (LIDAR) topographic survey of Tegucigalpa and ground surveys at 11 bridges. Because of the high cost of obtaining the LIDAR elevation data, the extent of mapping was limited to areas of high population where flooding is expected to cause the worst damage. The findings in this report are based on the condition of the river channel and floodplains on March 1, 2000, when the LIDAR data were collected and on March 2000 and April 2001 when the ground surveys of bridges were made.

Acknowledgments

We acknowledge USAID for funding this project; Jeff Phillips of the USGS for providing data and field support while we were in-country; and Roger Bendeck, a Honduran interpreter, for being an indispensable guide, translator, and instrument man during our field trips.

DESCRIPTION OF STUDY AREA

The main river in the Tegucigalpa study area is Río Choluteca, which flows from south to north through the center of the city. In the area of Tegucigalpa known as La Bolsa, Río Guacerique flows from the west and meets with Río Grande, flowing from the south, to become Río Choluteca. About 1 kilometer (km) north of this confluence, Río Chiquito flows into Río Choluteca. The study area includes the river channel and floodplains of Río Choluteca, beginning about 2.7 km downstream of the Puente El Chile bridge and extending upstream to the confluence of Río Grande and Río Guacerique; from the mouth of Río Chiquito upstream 1.36 km; from the mouth of Río Guacerique upstream 1.27 km; and from the mouth of Río Grande upstream 4.80 km (figure 1). The headwaters for Río Guacerique and Río Grande are in the Montaña de Rincon Dolores and Montaña de Azacualpa to the south and west of Tegucigalpa, and the headwaters for Río Chiquito are in the Montaña de San Juancito to the east of Tegucigalpa.

The streambed material of all the rivers ranges from sand and gravel to cobbles and small boulders in the main channel. The overbank areas are city streets and buildings in most areas. The slope of the river reaches varies from 0.0091 on the steepest section of the upper end of Río Chiquito to 0.0034 on the flattest section of the upper Río Choluteca.

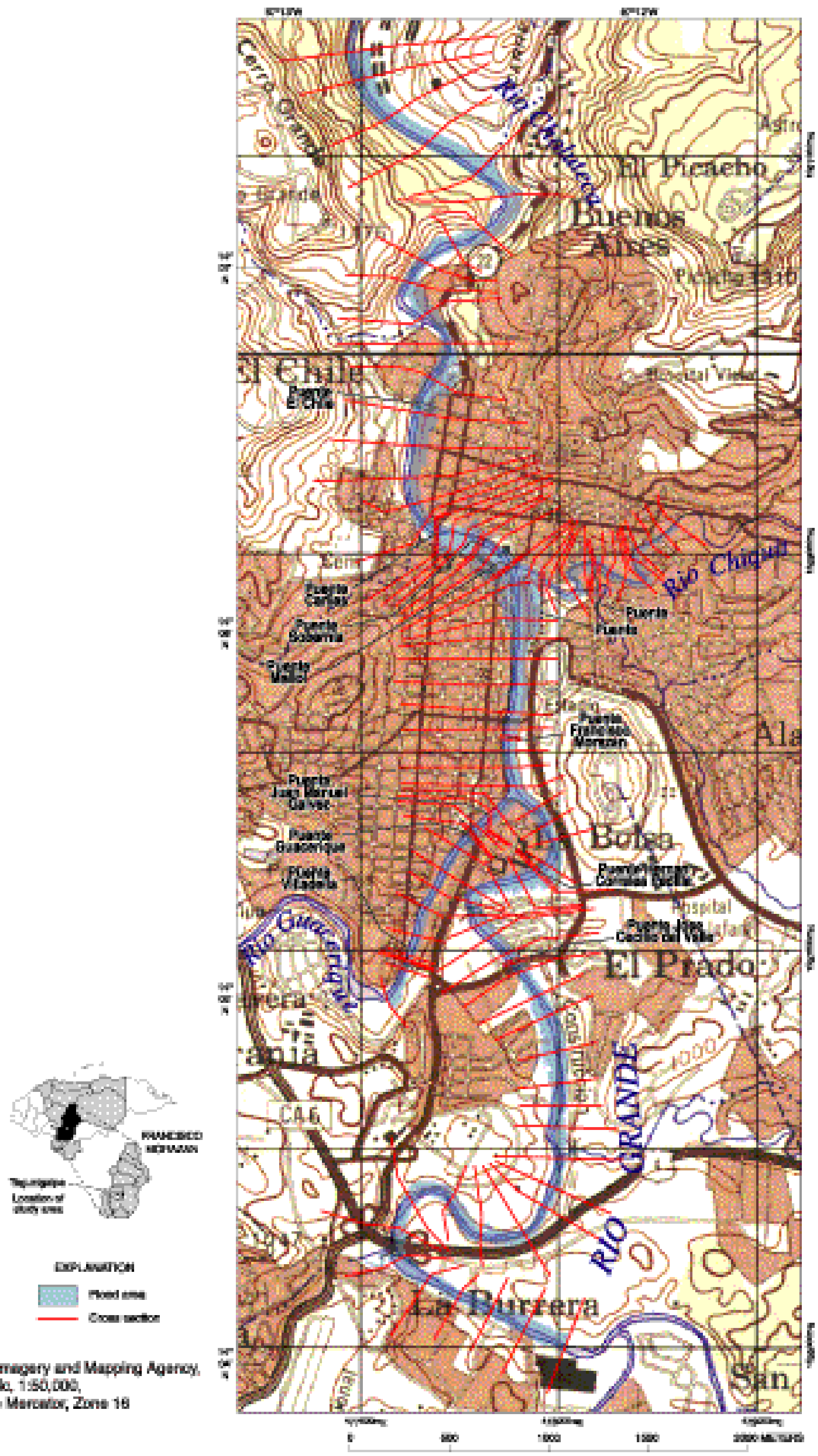

Figure 1. Location of study area and cross sections, and the area of inundation for the 50-year flood on Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa, Honduras.

FIFTY-YEAR FLOOD DISCHARGE

There are no long-term streamflow records from gaging stations near Tegucigalpa on the four study rivers. Therefore, 50-year-flood discharges were estimated using the following regression equation, which was developed using data from 34 streamflow stations throughout Honduras with more than 10 years of annual peak flow record, that relates the 50-year peak flow with drainage basin area and mean annual precipitation (Mastin, 2002).

$$Q_{50} = 0.0788(DA)^{0.5664}(P)^{0.7693}\,, \qquad (1)$$

where
- Q_{50} is the 50-year-flood discharge, in cubic meters per second (m^3/s),
- DA is drainage area, in square kilometers (km^2), and
- P is mean annual precipitation over the basin, in mm.

The standard error of estimate of equation 1, which is a measure of the scatter of data about the regression equation, is 0.260 log unit, or 65.6 percent. The standard error of prediction, which is a measure of how well the regression equation predicts the 50-year-flood discharge and includes the scatter of the data about the equation plus the error in the regression equation, equals 0.278 log unit, or 71.3 percent.

The drainage area of each of the rivers (table 1) was determined using a geographic information system (GIS) program to analyze a digital elevation model (DEM) with a 93-meter cell resolution from the U.S. National Imagery and Mapping Agency (David Stewart, USGS, written commun., 1999). The mean annual precipitation over the drainage basins was determined using a GIS program to analyze a digitized map of mean annual precipitation at a scale of 1:2,500,000 (Morales-Canales, 1997–1998, p. 15).

The 50-year-flood discharges estimated from equation 1 are given in table 1 for the Tegucigalpa study area. The sum of the 50-year-flood discharges at the confluence of any two streams is greater than the discharge of the outflow because 50-year floods are not likely to occur simultaneously on all streams.

Table 1. Drainage area, mean annual precipitation, and estimated discharge for the 50-year flood for the Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa, Honduras

[**Abbreviations**: km^2, square kilometers; mm, millimeters; m^3/s, cubic meters per second]

River	Drainage area (km^2)	Mean annual precipitation for the basin (mm)	Estimated 50-year-flood discharge from equation 1 (m^3/s)
Río Chiquito	77	1,481	254
Río Guacerique	251	1,402	475
Río Grande	453	1,402	663
Río Choluteca at confluence with Río Chiquito	715	1,402	859
Río Choluteca at downstream end of study area	804	1,409	922

WATER-SURFACE PROFILES OF THE 50-YEAR FLOOD

Once a 50-year flood discharge has been estimated, a profile of water-surface elevations along the course of the river can be estimated for the 50-year flood with a step-backwater model, and later used to generate the flood-inundation maps. The U.S. Army Corps of Engineers HEC-RAS modeling system was used for step-backwater modeling. HEC-RAS is a one-dimensional, steady-flow model for computing water-surface profiles in open channels, through bridge openings, and over roads. The basic required inputs to the model are stream discharge, cross sections (geometry) of the river channels and floodplains perpendicular to the direction of flow, bridge geometry, Manning's roughness coefficients (*n* values) for each cross section, and boundary conditions (U.S. Army Corps of Engineers, 1998).

Cross-section geometry was obtained from a high-resolution DEM created from an airborne LIDAR survey. The LIDAR survey was conducted by personnel from the University of Texas. A fixed-wing aircraft with the LIDAR instrumentation and a precise global positioning system (GPS) flew over the study area on March 1, 2000. The relative accuracy of the LIDAR data was determined by comparing LIDAR elevations with GPS ground-surveyed elevations at two locations at a total of 231 points in the Tegucigalpa study area. The mean difference between the two sets of elevations is 0.134 and 0.152 meter, and the standard deviation of the differences is 0.097 and 0.071 meter. The LIDAR data were filtered to remove vegetation while retaining the buildings to create a "bare earth" elevation representation of the floodplain. The LIDAR data were processed into a GIS GRID (Arc/Info™) raster coverage of elevations at a 1.5-meter cell resolution. The coverage was then processed into a triangular irregular network (TIN) GIS coverage. Cross sections of elevation data oriented across the floodplain perpendicular to the expected flow direction of the 50-year-flood discharge (figure 1) were obtained from the TIN using HEC-GeoRAS, a pre- and post-processing GIS program designed for HEC-RAS (U.S. Army Corps of Engineers, 2000). The underwater portions of the cross sections cannot be seen by the LIDAR system. However, because the LIDAR surveys were conducted during a period of extremely low flows, the underwater portions were assumed to be insignificant in comparison with the cross-sectional areas of flow during a 50-year flood; therefore, they were not included in the model.

Ground surveys of 11 bridges that could affect the hydraulics of flow during a 50-year flood were made March 2000 and April 2001. Three bridges were surveyed on Río Guacerique, two on Río Chiquito, two on Río Grande, and four on Río Choluteca. Two bridges on Río Choluteca were under construction during the April 2001 field survey, one to replace Puente El Chile and one near the stadium, Puente Juan Ramon Molina. They were not field surveyed or included in the hydraulic model. On Río Chiquito, one bridge near the upstream end of the study area was overlooked and not field surveyed or included in the hydraulic model. One bridge at the upstream end of the study area on Río Grande was not field-surveyed or included in the hydraulic model because it has a large opening that is not expected to constrict the flow or affect the water-surface elevation of the 50-year flood. If the bridges that were not included in the hydraulic model do constrict the flow of the 50-year flood, then the water-surface elevations will be higher than those estimated in this report and the area of inundation will be larger.

Most hydraulic calculations of flow in channels and overbank areas require an estimate of flow resistance, which is generally expressed as Manning's roughness coefficient, *n*. The effect that roughness coefficients have on water-surface profiles is that as the *n* value is increased, the resistance to flow increases also, which results in higher water-surface profiles. Roughness coefficients (Manning's *n*) for the Tegucigalpa study reaches were estimated from field observations and digital photographs taken during field visits to survey the geometry of the bridges. The *n* values estimated for the main channels ranged from 0.037 to 0.046, and the *n* values estimated for the floodplain areas ranged from 0.050 to 0.075.

Step-backwater computations require a water-surface elevation at either the downstream end of the stream reach for flows in the subcritical flow regime or at the upstream end of the reach for flows in the supercritical flow regime as a boundary condition. A water-surface elevation of 906.81 meters at cross section 0.089, the farthest downstream cross section in the Tegucigalpa step-backwater model, was estimated by a slope-conveyance computation assuming an energy gradient of 0.004. The energy gradient was estimated to be equal to the slope of the main channel bed. The computed water-surface elevations at the first few cross sections upstream may differ from the true elevations if the estimated boundary condition elevation is incorrect. However, if the error in the estimated boundary condition is not large, the computed profile asymptotically approaches the true profile within a few cross sections. At the mouth of a tributary stream, the boundary condition is the 50-year-flood water-surface elevation at the first downstream cross section, with the assumption that flow is subcritical.

The Tegucigalpa step-backwater model provided estimates of water-surface elevations at all cross sections for the 50-year-flood discharge (table 2 and figures 2-4).

Table 2. Estimated water-surface elevations for the 50-year flood on Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa, Honduras

[**Cross-section stationing**: distance upstream from an arbitrary point near the model boundary or river confluence with Río Choluteca; **Minimum channel elevation**, **Water-surface elevation**: elevations are referenced to the World Geodetic System Datum of 1984; **Abbreviations**: km, kilometers; m, meters; m^3/s, cubic meters per second]

Cross-section stationing (km)	50-year peak flow (m^3/s)	Minimum channel elevation (m)	Average velocity of flow (m/s)	Water-surface elevation (m)	Cross-section stationing (km)	50-year peak flow (m^3/s)	Minimum channel elevation (m)	Average velocity of flow (m/s)	Water-surface elevation (m)
Río Grande									
9.776	663	945.55	2.74	949.19	6.356	663	929.64	2.93	934.62
9.552	663	943.85	2.35	948.70	6.302	663	929.24	2.64	934.55
9.359	663	943.30	3.10	948.01	6.300 (Puente Jose Cecilio del Valle)				
9.182	663	942.98	3.12	947.48	6.286	663	929.24	2.78	934.34
9.003	663	942.44	4.36	946.13	6.239	663	928.54	2.52	934.31
8.825	663	940.68	2.32	945.98	6.123	663	928.52	3.65	933.59
8.662	663	940.52	3.61	945.02	6.047	663	928.41	3.15	933.39
8.501	663	939.95	3.85	943.90	6.001	663	928.00	2.81	933.28
8.263	663	938.41	2.67	943.18	5.930	663	927.63	2.93	933.01
8.019	663	936.71	3.23	942.17	5.853	663	927.43	2.67	932.82
7.795	663	935.35	2.48	941.80	5.742	663	927.65	2.89	932.30
7.624	663	934.18	2.87	941.34	5.624	663	926.74	2.41	932.17
7.516	663	934.25	5.38	939.61	5.524	663	926.42	1.85	932.08
7.362	663	934.54	2.75	938.64	5.522 (Puente Dr. Hernan Corrales Padilla)				
7.197	663	934.52	3.26	937.87	5.508	663	926.25	1.65	931.85
7.090	663	933.82	2.38	937.68	5.460	663	926.35	1.91	931.75
6.973	663	933.52	3.58	936.82	5.317	663	925.51	4.23	930.63
6.809	663	931.44	2.55	936.09	5.229	663	925.78	4.11	929.99
6.617	663	930.30	2.75	935.33	5.129	663	924.82	2.46	929.98
6.503	663	930.21	2.56	935.12					

Table 2. Estimated water-surface elevations for the 50-year flood on Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa, Honduras—*Continued*

Cross-section stationing (km)	50-year peak flow (m^3/s)	Minimum channel elevation (m)	Average velocity of flow (m/s)	Water-surface elevation (m)
Río Choluteca				
4.971	859	924.50	3.22	929.40
4.871	859	923.94	2.88	929.23
4.787	859	923.68	2.84	929.07
4.730	859	923.29	2.81	928.96
4.728 (Puente Francisco Morazan)				
4.712	859	923.29	2.87	928.83
4.675	859	922.75	2.91	928.74
4.589	859	922.56	3.31	928.41
4.442	859	922.08	2.42	928.33
4.312	859	922.51	2.72	928.05
4.214	859	921.90	2.51	927.91
4.114	859	921.74	1.75	927.89
3.937	859	921.53	1.69	927.74
3.827	922	921.45	1.94	927.64
3.825 (Puente Mallol)				
3.811	922	921.45	2.07	927.32
3.706	922	920.87	1.97	927.24
3.627	922	920.51	1.60	927.23
3.625 (Puente Sobernia)				
3.610	922	920.51	1.66	927.05
3.541	922	920.49	1.61	927.01
3.473	922	920.21	1.40	926.99
3.397	922	919.01	1.54	926.95
3.395 (Puente Carlias)				
3.383	922	919.01	1.57	926.87
3.317	922	919.24	1.91	926.76
3.205	922	918.89	2.96	926.35
3.072	922	918.59	5.68	924.17
2.911	922	918.93	3.86	923.03
2.742	922	918.23	3.29	922.04
2.557	922	916.28	2.58	921.54
2.356	922	915.26	5.09	919.60
2.168	922	914.56	3.99	918.31
1.948	922	912.06	3.29	917.23
1.819	922	911.90	5.12	915.60
1.638	922	909.07	3.86	914.41
1.460	922	908.95	5.23	912.21
1.213	922	906.90	2.94	911.27
1.005	922	905.98	3.08	910.46
0.717	922	904.57	3.63	908.80
0.477	922	902.68	2.41	908.33
0.235	922	902.14	3.24	907.30
0.089	922	902.21	3.11	906.81
Río Guacerique				
1.274	475	931.24	1.94	937.09
1.091	475	930.04	5.99	934.76
1.050	475	930.76	4.22	935.04
1.048 (Puente Villadella)				
1.033	475	930.76	4.76	934.61
1.015	475	930.02	5.61	933.92
0.909	475	929.51	4.26	933.40
0.759	475	927.86	3.44	932.70
0.652	475	927.79	4.02	931.81
0.553	475	926.69	3.43	931.43
0.416	475	926.52	3.80	930.49
0.327	475	925.82	2.80	930.45
0.325 (Puente Guacerique)				
0.310	475	925.82	2.85	930.38
0.270	475	926.03	3.20	930.14
0.215	475	925.70	1.34	930.38
0.213 (Puente Juan Manuel Galvez)				
0.196	475	925.70	1.34	930.36
0.141	475	924.79	2.99	929.82
Río Chiquito				
1.364	254	934.97	3.51	938.57
1.285	254	933.92	5.03	936.99
1.200	254	931.51	3.19	936.14
1.124	254	931.12	2.91	935.86
1.070	254	930.25	4.71	934.69
0.926	254	928.26	1.92	932.43
0.815	254	927.20	2.92	931.84
0.729	254	926.72	4.37	930.47
0.677	254	925.99	4.63	929.51
0.653	254	925.61	1.23	929.76
0.648 (bridge)				
0.634	254	925.15	1.96	929.69
0.597	254	924.91	4.29	928.71
0.350	254	924.11	2.39	928.11
0.187	254	923.07	2.10	927.72
0.144	254	922.50	1.00	927.92
0.142 (bridge)				
0.127	254	922.50	1.02	927.87
0.070	254	922.61	1.20	927.80

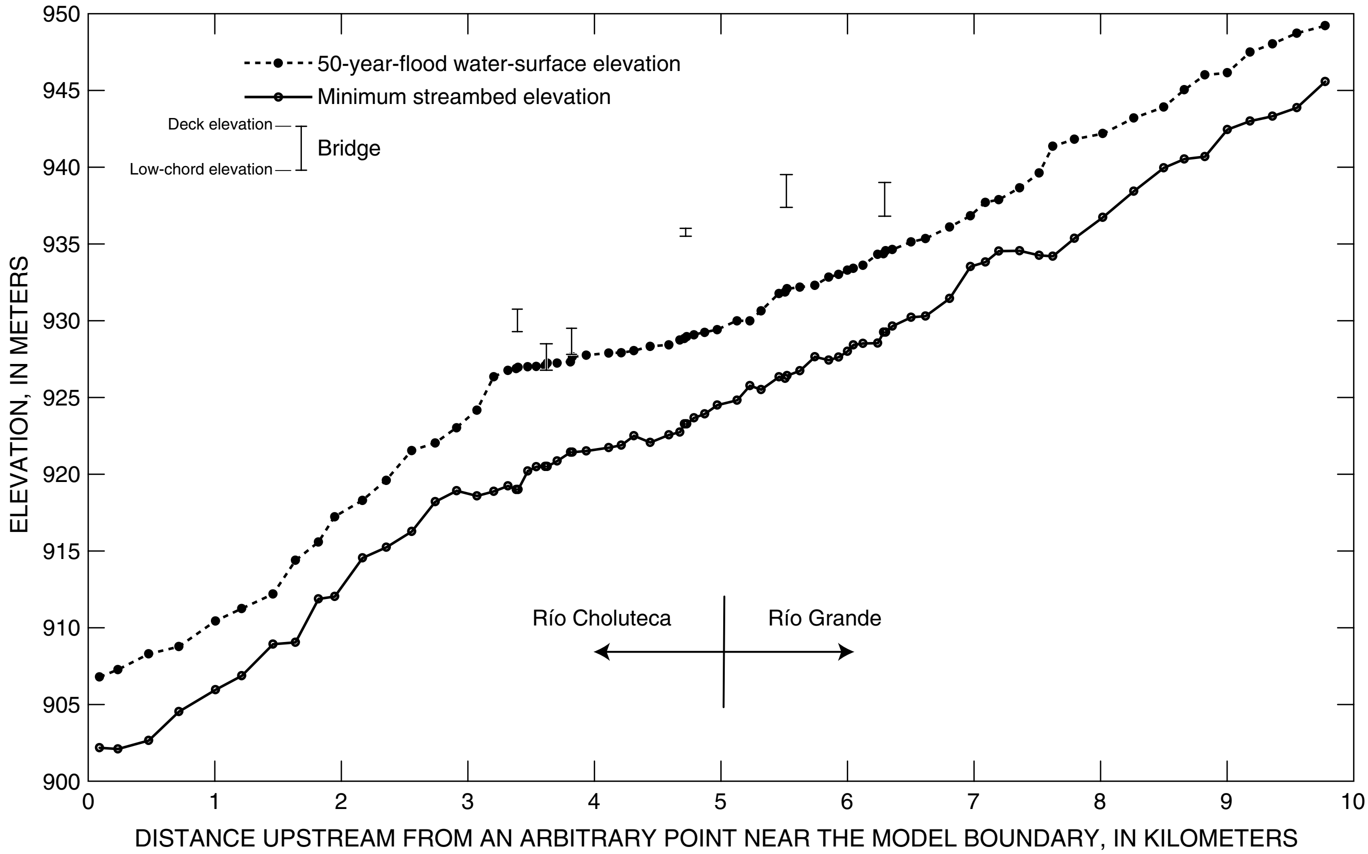

Figure 2. Water-surface profile, estimated using the step-backwater model HEC-RAS, for the 50-year flood on Río Choluteca and Río Grande at Tegucigalpa, Honduras.

Rio Grande becomes Río Choluteca at the confluence with Río Guacerique.

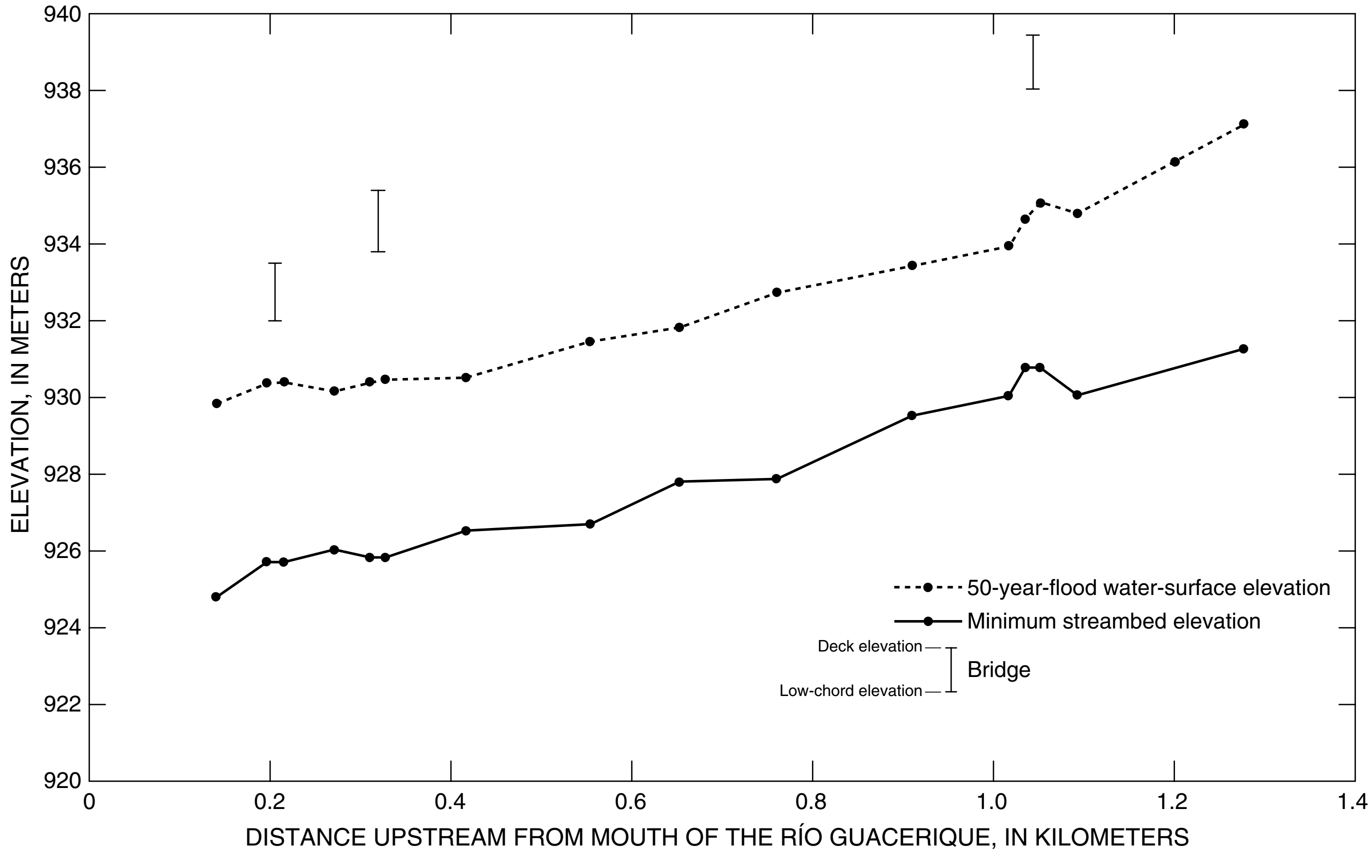

Figure 3. Water-surface profile, estimated using the step-backwater model HEC-RAS, for the 50-year flood on Río Guacerique at Tegucigalpa, Honduras.

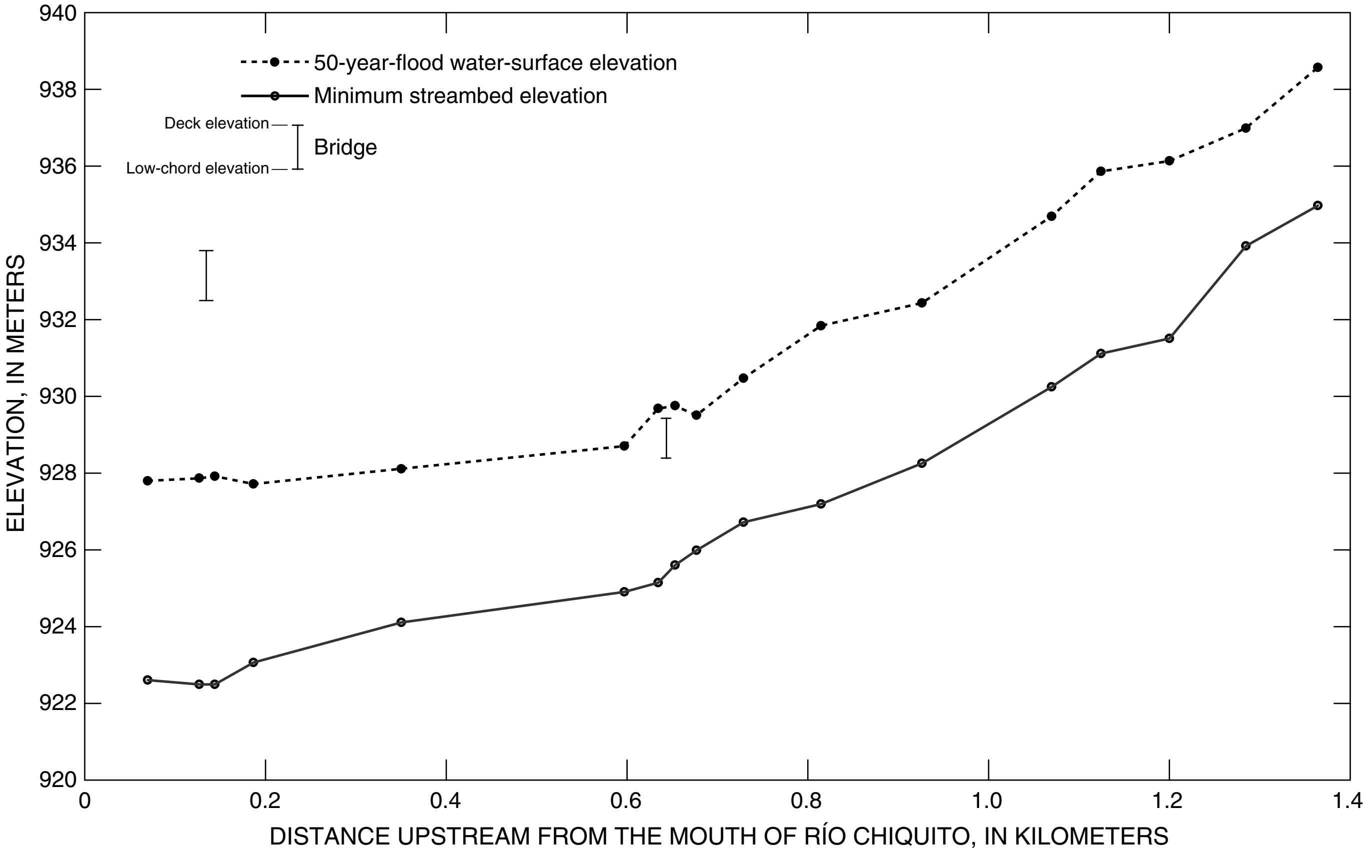

Figure 4. Water-surface profile, estimated using the step-backwater model HEC-RAS, for the 50-year flood on Río Chiquito at Tegucigalpa, Honduras.

FIFTY-YEAR FLOOD-INUNDATION MAPS

The results from the step-backwater hydraulic model were processed by the computer program HEC-GeoRAS to create GIS coverages of the area and depth of inundation for the study area. The GIS coverage of area of inundation was created by intersecting the computed water-surface elevations with the topographic TIN that was produced from the LIDAR data. This coverage was overlain on an existing 1:50,000 topographic digital raster graphics map (figure 1) produced by the National Imagery and Mapping Agency (Gary Fairgrieve, USGS, written commun., 1999). Depth of inundation at Tegucigalpa for a 50-year flood (figure 5) was computed by subtracting the topographic TIN from the water-surface elevation TIN to produce a grid with a cell size of 2 meters. The area of inundation is for the most part contained within the main channels of the rivers except in the area at the confluence of Río Choluteca and Río Chiquito and on Río Chiquito near the prison, where some flooding outside the main channel occurs. At the confluence, the 50-year flood flows over the left-bank approaches (looking downstream) to two bridges over Río Choluteca, Puente Mallol (cross section 3.825) and Puente Sobernia (cross section 3.625). Flow is slightly above the top of the bridge opening at Puente Sobernia. The only bridge where the computed water-surface elevation is above the bridge deck during the 50-year flood is the bridge near the prison on Río Chiquito (cross section 0.648).

The blue lines depicting the rivers on the digital raster graphics map used as the base map for figure 1 lie outside the 50-year-flood boundaries at some locations. This probably results from changes in the river course as a result of flood flows that occurred after the map was created, especially those that resulted from Hurricane Mitch.

The flood-hazard maps are intended to provide a basic tool for planning or for engineering projects in or near the floodplains of the Tegucigalpa study reaches. This tool can reasonably separate high-hazard from low-hazard areas in the floodplain to minimize future flooding losses. However, significant introduced or natural changes in main-channel or floodplain geometry or location can affect the area and depth of inundation. Also, encroachment into the floodplain with structures or fill will reduce flood-carrying capacity and thereby increase the potential height of floodwaters, and may increase the area of inundation. The area and depth of inundation maps are based on the topography surveyed in March 2000, which is known to have changed since that date at a dredging project on Río Choluteca between the Puente Sobrina and Puente Carlias (cross section 3.397) bridges and on Río Choluteca at the bridge reconstruction sites at Puente Juan Ramon Molina (cross section 4.675) and at Puente El Chile (near cross section 2.743).

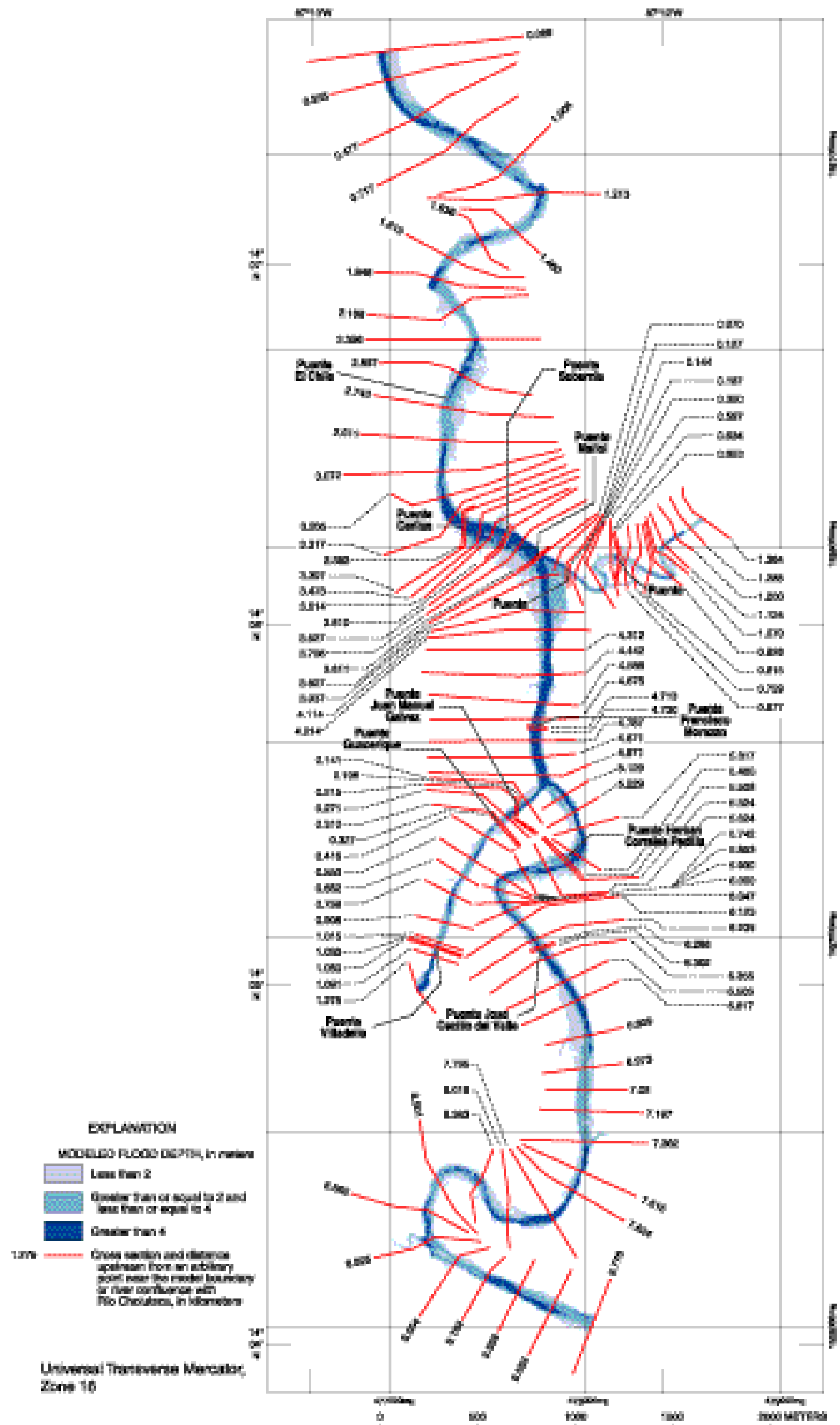

Figure 5. Depth of inundation for the 50-year flood and location of cross sections on Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa, Honduras.

DATA AVAILABILITY

GIS coverages of flood inundation and flood depths shown on the maps in figures 1 and 5 are available in the Municipal GIS project, a concurrent USAID-sponsored USGS project that will integrate maps, orthorectified aerial photography, and other available natural resource data for a particular municipality into a common geographic database. The GIS project, which is located on a computer in the Tegucigalpa municipality office, allows users to view the GIS coverages in much more detail than shown on figures 1 and 5. The GIS project will also allow users to overlay other GIS coverages over the inundation and flood-depth boundaries to further facilitate planning and engineering. Additional information about the Municipal GIS project is available on the Internet at the GIS Products Web page (http://mitchnts1.cr.usgs.gov/projects/floodhazard.html), a part of the USGS Hurricane Mitch Program Web site.

The GIS coverages and the HEC-RAS model files for this study are available on the Internet at the Flood Hazard Mapping Web page (http://mitchnts1.cr.usgs.gov/projects/floodhazard.html), which is also a part of the USGS Hurricane Mitch Program Web site.

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